

Pulmonary Capacity in Older Adults Before and After COVID-19 Infection

Capacidade Pulmonar em Pessoas Idosas Pré e Pós Infecção por COVID-19

Capacidad Pulmonar en Personas Mayores Antes y Después de la Infección por COVID-19

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RESUMO

Objetivo: Avaliar e comparar a capacidade pulmonar de idosos antes e após infecção por COVID-19. **Métodos:** Estudo de coorte retrospectivo com prontuários da UTI de um hospital do Distrito Federal, incluindo idosos infectados em 2022-2023 que realizaram espirometria antes e depois do diagnóstico confirmado por RT-PCR. Excluíram-se pacientes com cirurgia torácica recente, alterações cognitivas, comorbidades descompensadas ou ventilação mecânica contínua. Dados clínicos, sociodemográficos e espirométricos foram coletados e revisados por dois pesquisadores. Aplicaram-se teste de Shapiro-Wilk, teste t pareado, correlação de Pearson e regressão linear simples (alfa 5%). **Resultados:** Foram avaliados 32 pacientes (78,1% mulheres; idade média 68,87 anos; 87,5% com comorbidades), sendo 50% não vacinados. Não vacinados apresentaram maior massa corporal e IMC ($p < 0,05$). Observou-se redução significativa da função pulmonar em 100% da amostra após a infecção, com o drive respiratório prévio associado a menor perda funcional. **Conclusão:** O drive respiratório influencia positivamente a preservação da capacidade vital forçada pós-COVID-19, permitindo gerar uma equação preditiva para estimar essa perda. Não houve diferença significativa entre vacinados e não vacinados. O estudo incluiu apenas pacientes que obtiveram alta, não avaliando mortalidade ou recuperação pós-alta. **Implicações:** A equação baseada no drive respiratório pode auxiliar na previsão e monitoramento da disfunção respiratória em idosos pós-internação por COVID-19.

Descritores: Capacidade Pulmonar, Idoso, COVID-19, Função Pulmonar.

ABSTRACT

Objective: To assess and compare pulmonary capacity in older adults before and after COVID-19 infection. **Methods:** A retrospective cohort study was conducted using ICU medical records from a hospital in the Federal District, including older adults infected in 2022-2023 who underwent spirometry both before and after a COVID-19 diagnosis confirmed by RT-PCR. Patients with recent thoracic surgery, cognitive impairment, decompensated comorbidities, or continuous mechanical ventilation were excluded. Clinical, sociodemographic, and spirometric data were collected and independently reviewed by two researchers. Statistical analysis included Shapiro-Wilk test, paired t-test, Pearson correlation, and simple linear regression ($\alpha = 5\%$). **Results:** Thirty-two patients were evaluated (78.1% female; mean age 68.87 years; 87.5% with comorbidities), with 50% unvaccinated. Unvaccinated individuals had significantly higher body mass and BMI ($p < 0.05$). A significant decline in pulmonary function was observed in 100% of the sample after infection, with prior respiratory drive associated with less functional loss. **Conclusion:** Respiratory drive positively influences the preservation of forced vital capacity after COVID-19, enabling the development of a predictive equation for estimating this loss. No significant differences were found between vaccinated and unvaccinated groups. The study included only patients discharged after hospitalization, without assessing mortality or post-discharge recovery. **Implications:** The predictive equation based on respiratory drive may assist in forecasting and monitoring respiratory dysfunction in older adults following COVID-19 hospitalization.

Descriptors: Pulmonary Capacity, Older Adults, COVID-19, Pulmonary Function

RESUMEN

Objetivo: Evaluar y comparar la capacidad pulmonar de personas mayores antes y después de la infección por COVID-19. **Métodos:** Estudio de cohorte retrospectivo con historias clínicas de la UCI de un hospital del Distrito Federal, incluyendo a personas mayores infectadas en 2022-2023 que se realizaron espirometría antes y después del diagnóstico confirmado por RT-PCR. Se excluyeron pacientes con cirugía torácica reciente, alteraciones cognitivas, comorbilidades descompensadas o ventilación mecánica continua. Se recopilaron y revisaron datos clínicos, sociodemográficos y espirométricos por dos investigadores. Se aplicaron la prueba de Shapiro-Wilk, la prueba t pareada, la correlación de Pearson y la regresión lineal simple (alfa 5%). **Resultados:** Se evaluaron 32 pacientes (78,1% mujeres; edad media 68,87 años; 87,5% con comorbilidades), siendo el 50% no vacunados. Los no vacunados presentaron mayor masa corporal e IMC ($p < 0,05$). Se observó una reducción significativa de la función pulmonar en el 100% de la muestra tras la infección, con el drive respiratorio previo asociado a una menor pérdida funcional. **Conclusión:** El drive respiratorio influye positivamente en la preservación de la capacidad vital forzada post-COVID-19, permitiendo generar una ecuación predictiva para estimar esta pérdida. No hubo diferencia significativa entre vacunados y no vacunados. El estudio incluyó solo a pacientes que recibieron el alta, sin evaluar mortalidad ni recuperación post-alta. **Implicaciones:** La ecuación basada en el drive respiratorio puede ayudar en la predicción y monitoreo de la disfunción respiratoria en adultos mayores tras la hospitalización por COVID-19.

Descritores: Capacidad Pulmonar, Adulto Mayor, COVID-19, Función Pulmonar.

ORIGINAL

Introduction

Senescence is a natural phenomenon that affects all living organisms and is characterized by a gradual loss of physiological functions over time (1). This process results in several alterations in the human body, including reduced tissue regenerative capacity, decreased bone density, and a decline in neuromuscular and cognitive functions (2).

These physiological changes can significantly impact the quality of life of older adults, making them more vulnerable to diseases and functional impairments. Among the various bodily functions affected by senescence, pulmonary function is one of the most notable, with a significant reduction in respiratory capacity and gas exchange efficiency, leading to marked pulmonary impairment (3).

During senescence, several structural and functional changes occur in the lungs and thoracic cage. These changes include a loss of pulmonary elasticity, decreased strength of respiratory muscles, and stiffening of the chest wall, resulting in reduced ventilatory efficiency (4).

Pulmonary capacity in older adults can be altered by various factors, including structural and functional changes in the respiratory system. The rigidity of the thoracic wall, decreased respiratory muscle strength, and reduced pulmonary elasticity are typical alterations associated with aging. In addition to these intrinsic factors, chronic conditions such as Chronic Obstructive Pulmonary Disease (COPD), cardiovascular diseases, and COVID-19 itself can exacerbate the impairment of pulmonary function in the elderly. Infection by SARS-CoV-2, for instance, has shown long-lasting effects on respiratory function, contributing to a more pronounced decline in pulmonary capacity among older survivors (3,5).

COVID-19, caused by the SARS-CoV-2 virus, has demonstrated devastating effects on respiratory function, especially in elderly populations. Infection by the virus can trigger an intense inflammatory response in the lungs, resulting in pneumonia and Acute Respiratory Distress Syndrome (ARDS), conditions that severely compromise gas exchange (6). In older adults, these conditions are exacerbated due to the preexisting decline in pulmonary elasticity and respiratory muscle strength that naturally occurs with aging (7).

The main risks for elderly individuals infected with COVID-19 include the rapid progression to severe respiratory failure, a higher likelihood of secondary complications such as bacterial infections, and an elevated mortality rate compared to younger age groups. The presence of common comorbidities in the elderly – such as hypertension, diabetes, and cardiovascular diseases – further worsens the clinical picture and increases vulnerability to fatal outcomes (3). Ventilatory parameters, including Forced Expiratory Volume in the first second (FEV_1) and Forced Vital Capacity (FVC), are crucial indicators of pulmonary function. In older adults, COVID-19 infection tends to cause a marked decrease in these parameters due to inflammation and damage to lung tissues, resulting in inefficient gas exchange and reduced ventilatory performance (7).

The reduction in pulmonary capacity after COVID-19 can lead to lower exercise tolerance and difficulties in performing daily activities, negatively impacting quality of life. Dyspnea and persistent fatigue are common symptoms that affect the ability of older adults to maintain an active and independent lifestyle, increasing the risk of depression and social isolation (6).

The hypothesis established for this study is that the elderly population post-COVID-19 presents significant and lasting deterioration in pulmonary function. Specifically, it is expected to observe a reduction in ventilatory parameters such as Forced Expiratory Volume in the first second (FEV_1) and Forced Vital Capacity (FVC) when compared to pre-infection levels.

This study aims to compare the pulmonary capacity of elderly individuals before and after COVID-19 infection during hospitalization in the Intensive Care Unit.

Method

This is a retrospective cohort study, given that its retrospective nature derives from the use of medical records obtained from the Intensive Care Unit (ICU) of a medium- and high-complexity hospital in the Federal District, during the years 2022 and 2023. The study sought data from spirometry tests of elderly patients who were already undergoing treatment – either for transient intercurrent conditions or for chronic noncommunicable diseases – and who were infected with COVID-19 during this period. The entire study followed current ethical guidelines, having been submitted to and approved by the Research Ethics Committee for Human Subjects (CEP) under approval number 7.691.935, and it complied fully with the General Data Protection Law (LGPD).

Medical records were included if the patients were receiving outpatient treatment, had contracted COVID-19 during treatment, and had undergone spirometry testing both before and after the COVID-19 diagnosis, confirmed by the Reverse Transcription Polymerase Chain Reaction (RT-PCR) test. Exclusion criteria included patients who had undergone thoracic surgery within six months before or after spirometry testing, those with cognitive impairments, decompensated comorbidities, incomplete or illegible records, or those who required mechanical ventilation or continuous oxygen therapy.

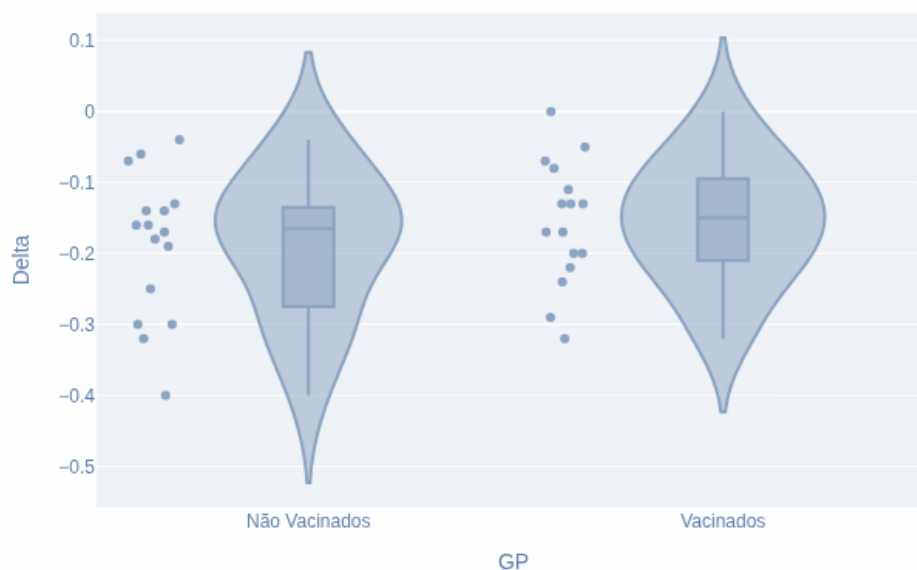
For data collection, information was extracted from the electronic medical records of the Hospital das Forças Armadas (HFA), including spirometric evaluations, clinical diagnoses, medical history, and sociodemographic data. In the first stage, medical records of patients treated at the hospital were reviewed. In the second stage, the records of individuals aged 60 years or older who had a confirmed diagnosis of COVID-19 were selected.

Data collection and extraction were carried out using a standardized form specifically developed for this study. Clinical data were extracted, including comorbidities, vaccination status, hospitalization history, and length of hospital stay, as well as spirometric variables such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV_1), Peak Expiratory Flow (PEF), Forced Expiratory Volume in six seconds (FEV_6), Inspiratory Capacity (IC), and the FVC/FEV_1 ratio. These data were collected at two time points: before COVID-19 infection (pre-infection) and after recovery (post-infection).

To ensure data accuracy, all records were independently reviewed by two researchers. In case of disagreement, a third researcher was consulted for validation. Additionally, a temporal pairing approach was applied, selecting spirometry tests performed closest to the infection (pre-infection) and the first test after recovery (post-infection), within a minimum of 30 days and a maximum of 180 days after hospital discharge. This approach ensured the consistency and reliability of the collected data.

The linear regression model yielded $F(1,30) = 2295.62$, $p < 0.001$; $R^2 = 0.987$, indicating that for every 1 L of pre-infection FVC, the post-infection FVC can be estimated as $0.156 + 1.0006 \times \text{FVC}_{\text{post}}$. Regarding functional capacity across pre- and post-infection time points, vaccination status did not emerge as a determining factor for significant differences in Forced Vital Capacity (FVC). Before infection, the mean FVC was 2.81 ± 0.52 L for GV and 2.89 ± 1.06 L for GNV ($p = 0.792$). After infection, FVC values were 2.66 ± 0.54 L for GV and 2.71 ± 1.04 L for GNV, also without statistical significance ($p = 0.679$). The variation (Δ) between pre- and post-infection FVC was -0.16 ± 0.09 L for GV and -0.19 ± 0.10 L for GNV, with $p = 0.76$, confirming no significant difference between groups, as illustrated in Figure 2.

Figure 2. - Comparison of changes (Δ) in pulmonary vital capacity between pre- and post-COVID-19 infection following ICU admission (Unvaccinated group: $n = 16$; Vaccinated group: $n = 16$) ($p = 0.76$)



Discussion

The linear regression model used demonstrated a high predictive capacity for post-infection Forced Vital Capacity (FVC), with statistically significant results ($F(1,30) = 2295.62$, $p < 0.001$; $R^2 = 0.987$), indicating that 98.7% of the variability in post-infection FVC can be explained by pre-infection FVC values. The resulting equation (post-infection FVC = $0.156 + 1.0006 \times \text{pre-infection FVC}$) reinforces the stability of pulmonary function in the face of infection, suggesting that individuals with greater pulmonary functional reserve tend to maintain this capacity even after respiratory compromise.

Findings from previous scientific literature (8,9) have attributed better cardiorespiratory condition to a lifestyle that enhances respiratory capacity, as a result of chronic adaptations in the cardiorespiratory system. Such adaptations allow for more efficient oxygen utilization and lead to morphological changes in cellular oxidative capacity and ventilatory organs (10,11), providing individuals with a protective factor against adverse outcomes resulting from COVID-19 infection (8,9,12).

Regarding the influence of vaccination history, the data reveal no statistically significant difference between vaccinated (GV) and unvaccinated (GNV) groups at both pre-infection (GV: 2.81 ± 0.52 L; GNV: 2.89 ± 1.06 L; $p = 0.792$) and post-infection moments (GV: 2.66 ± 0.54 L; GNV: 2.71 ± 1.04 L; $p = 0.679$), with similar variation deltas (-0.16 ± 0.09 L for GV and -0.19 ± 0.10 L for GNV; $p = 0.76$). These findings indicate that, although vaccination is widely recognized for reducing the severity and mortality of acute respiratory infections (13,14)—as demonstrated in population-based studies showing vaccine effectiveness above 70% in preventing deaths from severe COVID-19 (SRAG-COVID-19)—its direct influence on spirometric parameters, such as FVC, may be limited in young and healthy populations, as also observed in studies involving young smokers (4).

From a clinical perspective, these results suggest that in individuals without preexisting respiratory comorbidities, acute respiratory infection may not significantly compromise pulmonary function, regardless of vaccination status (15). However, it is important to emphasize that vaccination remains an essential strategy for preventing severe complications, particularly in vulnerable groups such as the elderly and patients with chronic pulmonary diseases, for whom influenza and pneumococcal vaccination has been shown to reduce exacerbations and hospitalizations (15–17). Thus, although the present study did not demonstrate a direct impact of vaccination on mortality outcomes, its role in the overall protection of respiratory health remains undeniable.

Senescence is a natural physiological process characterized by the progressive loss of homeostasis and the regenerative capacity of tissues, directly affecting the function of several systems, including the respiratory system (18,19). In the elderly, structural changes such as decreased pulmonary elasticity, stiffening of the thoracic wall, and reduced strength of the respiratory muscles contribute to lower ventilatory efficiency, making this population particularly vulnerable to respiratory infections, such as that caused by SARS-CoV-2 (3,7).

COVID-19 infection, especially in its severe form, has proven devastating to pulmonary function, frequently progressing to viral pneumonia and Acute Respiratory Distress Syndrome (ARDS) (6,20). These events lead to diffuse alveolar inflammation, pulmonary fibrosis, and impaired gas exchange, directly affecting spirometric parameters such as Forced Expiratory Volume in the first second (FEV_1) and Forced Vital Capacity (FVC) (2). In older adults, the presence of comorbidities such as hypertension, diabetes, and obesity increases the risk of unfavorable outcomes, with a higher incidence of respiratory failure and mortality (21).

In this context, the present study aimed to evaluate the pulmonary capacity of elderly individuals before and after COVID-19 infection, focusing on FVC. The central hypothesis predicted a significant and lasting deterioration of pulmonary function post-infection, even in patients who were discharged from the hospital. To this end, a retrospective cohort study was conducted using medical records of patients admitted to the ICU between 2022 and 2023, with spirometric data available for pre-infection and 30 to 180 days post-discharge periods.

The sample consisted of 32 individuals, mostly female (78.1%) and aged 60 years or older, showing a high prevalence of comorbidities (87.5%), corroborating existing literature on the risk profile of the elderly population in the face of COVID-19 (22,23). Stratification between vaccinated (GV) and unvaccinated (GNV) individuals revealed significant differences in body mass and body mass index (BMI), with higher values in the unvaccinated group ($p = 0.026$ and $p = 0.017$, respectively), suggesting possible

metabolic and inflammatory implications associated with the absence of immunization (24,25).

The main findings of the study confirmed the initial hypothesis: there was a significant reduction ($p < 0.05$) in pulmonary function in 100% of the participants, as evidenced by the decline in FVC values after infection. This decrease is associated with persistent symptoms such as dyspnea and fatigue, which compromise quality of life and functional autonomy in older adults, even after clinical recovery (26).

As a limitation, it should be noted that the study included only individuals who survived the infection and were discharged from the ICU, excluding patients who died or presented severe sequelae. In addition, long-term outcomes—such as complete functional recovery or quality of life six months or more after hospital discharge—were not assessed. Future studies should consider these variables, as well as expand the sample size and include multicenter analyses to increase representativeness.

Conclusion

The results indicate that previous respiratory drive positively influenced the reduction of post-COVID infection spirometric parameters in elderly individuals who had been hospitalized, allowing the development of a predictive equation for the loss of forced vital capacity (FVC) measured by spirometry. However, no statistically significant differences were identified in forced vital capacity between elderly individuals with or without a vaccination history for COVID-19.

It is important to emphasize that this study included only individuals who were discharged after hospitalization due to COVID-19 viral infection; therefore, mortality outcomes as well as quality and duration of post-discharge recovery were not within the scope of this investigation.

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